1 **SYSTEM AND METHOD FOR DECODING BARCODES USING DIGITAL**

2 **IMAGING TECHNIQUES**

3

4 **FIELD OF THE INVENTION**

5 The present invention relates generally to the field

6 of barcode scanning and analyzation using a mobile device.

7 More specifically, the present invention operates by

8 acquiring barcode images using a camera phone, sending the

9 barcode images to a server, and subsequently decoding the

10 barcode information from the barcode images.

11

12 **PARENT CASE TEXT**

13 This application claims the benefit of provisional

14 application No. 60/511,703 filed October 17, 2003.

15

16 **BACKGROUND OF THE INVENTION**

17 Barcodes have been utilized for identifying and

18 pricing objects for more than thirty years. Most

19 typically, barcodes are used in retail to identify the

20 price of an item of merchandise. For example, a gallon of

21 milk may contain a barcode that, when scanned, will notify

22 the cashier of the price of the milk.

23 Yet in recent years, barcodes have acquired new

24 purposes as computers and barcode scanners have become more

1 portable. The circuitry required to scan a conventional

2 one-dimensional barcode can now be housed in a device as

3 small as a typical keychain. As a result, many mobile

4 telephones, personal digital assistants ("PDAs"), and

5 pagers can be retrofitted with or connected to a laser-

6 based scanning device. This allows the mobile device to

7 function as a scanner capable of storing hundreds or

8 thousands of scanned barcodes.

9 Mobile devices with attached scanners have allowed for

10 the development of a new niche in the wireless electronics

11 business. Some companies have developed software and

12 hardware which allows a user to scan any barcode and be

13 redirected to media information (e.g., a website, product

14 description, price, etc.) about the scanned product. These

15 programs provide a link between the physical and online

16 world which previously did not exist.

17 However, mobile devices with attached scanners possess

18 some drawbacks which have curtailed their expansion into

19 the mobile marketplace. First, there are few mobile

20 devices produced for the general public that contain

21 integrated laser-based scanners. Therefore, for a user to

22 acquire scanning capability for a mobile device, he/she

23 must purchase additional equipment. The additional

1 scanning equipment also adds size and weight to the mobile

2 device, thereby reducing its mobility.

3   Currently, many cell phones and mobile devices are

4 available with built-in cameras. The explosion of the

5 availability of affordable digital cameras and their

6 inclusion into mobile devices is driven by several factors.

7 One of the most important is the recent availability of

8 inexpensive image sensors based on CMOS technology. The

9 cameras on these devices provide a means for capturing the

10 barcode information which was previously only accessible

11 via a laser-based scanner. Decoding barcode images from

12 digital cameras included in mobile devices presents several

13 difficult problems. These problems go well beyond the

14 challenges addressed in commercial barcode readers.

15 Barcode decoding algorithms from commercial products will

16 not consistently decode images from a consumer portable

17 device. Some of these problems are addressed below:

18 *Lighting:*

19   Most mobile devices with integrated digital cameras do

20 not have built-in flashes and rely solely on the ambient

21 light for illumination. Using highly variable ambient

22 light makes pattern recognition much more difficult.

23 Shadows, shading across the length of a barcode,

24 overexposure, underexposure, and similar problems that are

1 typical of any camera not utilizing a flash can foil

2 traditional barcode decoding algorithms that are designed

3 for highly controlled lighting environments.

4 *Size:*

5   The distance between a digital camera and its target

6 object is not usually rigidly controlled. This translates

7 into a large range of possible sizes (magnifications) that

8 a barcode can have on a fixed size image sensor.

9 *Skew:*

10   As any photographer knows, taking pictures at an angle

11 changes the apparent shape of the object to a viewer. A

12 barcode with a rectangular shape, when viewed straight-on,

13 can look like a trapezoid (or irregular quadrilateral) when

14 viewed from an angle. The location and addressing of image

15 pixels for a barcode change dramatically when viewed from

16 the side, or tilted. Algorithms to decode barcodes from

17 digital images must be able to address images distorted

18 from skewed viewing angles.

19 *Color Imagers:*

20   Consumer oriented devices such as mobile handsets

21 generally are designed with color image sensors. However,

22 barcode scanning typically operates best with gray-scale

23 information. Color data typically requires three times the

24 amount of storage and handling required by gray-scale.

1   Data needs to be transferred through the camera's CPU and

2   memory to be processed. For color imagers, specific image

3   processing algorithms are required in order to avoid

4   problematic image artifacts during the translation from

5   color to grayscale.

6   *Focus:*

7   Digital cameras for portable devices are usually

8   designed to work at a variety of distances. The need for a

9   wider range of focus in cameras results in a trade off

10 between the cost of the lens component and the sharpness of

11 a typical image. Decoding algorithms for embedded digital

12 cameras must be able to cope with a moderate degree of

13 focus problems.

14 *Low-cost lens components:*

15   In order to meet cost constraints of many portable

16 device markets, manufacturers often compromise on the

17 optical quality of camera lenses. This can present

18 decoding technology with a different set of challenges from

19 the simple focal length based focus problem noted above.

20 Low-cost lens components can produce image distortions that

21 are localized to a specific region or form a changing

22 gradient across the image. This requires additional

23 sophistication for decoding algorithms.

24 *Limited resolution:*

1   The cost of a digital imaging CMOS sensor increases as

2   the number of image pixels increases. Although the Asian

3   market has seen the release of general purpose consumer

4   devices like PDAs and cell phones with "megapixel" image

5   resolution, it is unlikely these devices will be released

6   in the mainstream European and North American markets in

7   the near future. With fewer pixels to work with, it is

8   significantly more difficult to reliably decode barcodes

9   from images.

10   *Limited Processing Power:*

11   Decoding barcodes from images requires a great deal of

12   processing power to correctly extract the barcode

13   information from the image. Most camera phones do not have

14   this level of processing power mainly due to size

15   constraints. Also, processing digital images would greatly

16   reduce the battery life of the mobile device.

17   *Access:*

18   In many instances, mobile devices do not include an

19   application program interface ("API") for the integrated

20   digital camera. Therefore, access to the control and

21   function of the camera may be prohibited. Without direct

22   control of the functions of the camera, it would be

23   difficult to develop programs specifically for the mobile

24   device which are capable of decoding barcodes.

1   Based on the aforementioned described problems with

2   mobile devices and digital imaging, there clearly exists a

3   need for a system capable of capturing, decoding, and

4   analyzing barcode information obtained from a digital

5   camera enabled mobile device. Such a system would enable

6   the average mobile device user to accurately and reliably

7   scan and decode any barcode available.

8

9   **SUMMARY OF THE INVENTION**

10   The present invention provides a system and method

11   designed to successfully process and decode barcodes

12   acquired via digital imaging techniques. The invention

13   empowers a user to use a cell-phone or PDA equipped with a

14   digital camera to scan barcodes (one-dimensional and two-

15   dimensional) or any other similar machine-readable code.

16   The image acquired with the digital camera (built-in or

17   attached) of the cell phones /PDAs/Pocket PCs is sent to a

18   server via a wireless network and subsequently decoded to

19   extract the barcode information. This information is then

20   processed by the server and relayed back to the user in a

21   variety of ways.

22   To utilize the system of the present invention, a user

23   first initializes the digital camera on the camera phone by

24   loading an image acquisition program. Using the viewfinder

1   provided by the image acquisition program, the user takes a

2   picture of the desired barcode. Once the image has been

3   acquired, the user sends the image to a server via a

4   wireless network for decoding. Currently, most camera

5   phones and PDAs utilize XML to transfer digital images

6   through a wireless network. However, any protocol which

7   allows a digital image to be transferred from the camera

8   phone to the server wirelessly may be used with the present

9   invention.

10   Software located on the server (hereinafter referred

11 to as "ScanZoom") decodes the barcode utilizing a decoding

12 engine integral to the ScanZoom software. The barcode

13 decoding engine continuously runs in a loop until it's able

14 to decode barcode information from the barcode image. If

15 the barcode cannot be properly resolved, the user is

16 prompted to take another picture of the desired barcode.

17   After the barcode has been correctly resolved by the

18 server, the server processes the barcode information

19 accordingly. For example, the server may utilize the

20 barcode information to search for product information in a

21 product database or search engine. Alternatively, the

22 server may utilize the barcode information to search

23 multiple vendors for the lowest available price of the

24 scanned product. As should be evident to one skilled in

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1   the art, the barcode information may be utilizes in an

2   almost limitless variety of ways by the server.

3   After the server has processed the barcode

4   information, the media content is then sent back to the

5   user via the wireless network. The media content displayed

6   to the user depends entirely on the barcode scanned. For

7   example, if a user scans a barcode on a compact disc, the

8   ScanZoom application may send a MMS message to the camera

9   phone which directs the WAP browser located on the camera

10   phone website which allows the user to purchase the compact

11   disc electronically. As another example, if a user scans a

12   barcode located on a food item, the server may return a SMS

13   message to the mobile device indicating the nutritional

14   contents of the scanned item.

15   Therefore, it is an object of the present invention to

16   provide a system and method capable of accurately and

17   reliably decoding barcodes and other machine-readable codes

18   acquired via a digital camera connected to a mobile device.

19   Another object of the present invention is to provide

20   a software application and system which allows for the

21   decoding of barcodes in a wide range of conditions.

22   Yet another object of the present invention is to

23   provide a system and method for decoding barcodes which

1 does not require any software to be installed on the mobile

2 imaging device.

3   An additional object of the present invention is to

4 provide a method and system for decoding barcodes which is

5 quick and responsive.

6   Yet another object of the present invention is to

7 provide a method and system for decoding barcodes which is

8 robust under adverse lighting, imaging, and focusing

9 conditions.

10   Still another object of the present invention is to

11 provide a method and system for decoding multiple barcode

12 formats.

13   Another object of the present invention is to provide

14 a method and system which does not adversely affect device

15 performance, usability, or form factor.

16   Furthermore, an object of the present invention is to

17 provide a method and system for decoding barcodes which

18 does not significantly impact device power consumption nor

19 degrade general camera performance.

20   It is another object of the present invention to

21 provide a barcode decoding system which requires minimal or

22 no changes to the manufacturing process of the mobile

23 devices.

1   An additional object of the present invention is to

2 provide a barcode decoding system having a low incremental

3 cost per device.

4   Another object of the present invention is to provide

5 a highly reliable barcode decoding system requiring minimal

6 user support.

7   These and other objects of the present will be made

8 clearer with reference to the following detailed

9 description and accompanying drawings.

10

11 **BRIEF DESCRIPTION OF THE DRAWINGS**

12   FIG. 1 depicts a schematic diagram of the network

13 configuration utilized in the preferred embodiment of the

14 invention.

15   FIG. 2 depicts a flowchart showing the steps the

16 ScanZoom software utilizes to image and decode a barcode.

17   FIG. 3 depicts a schematic diagram showing the product

18 architecture of the ScanZoom software application.

19   FIG. 4A depicts a flowchart showing the process

20 utilized by the decoding engine to enhance an image before

21 decoding.

22   FIG. 4B depicts a flowchart showing the process

23 utilized by the decoding engine to decode a barcode.

1   FIG. 5A depicts a flowchart showing the process

2   utilized by the ScanZoom software to sharpen an image.

3   FIG. 5B depicts a typical barcode image acquired using

4   a digital camera.

5   FIG. 5C depicts the barcode of FIG. 5B after it has

6   undergone sharpening utilizing the sharpening filter

7   depicted in FIG. 5A.

8   FIG. 6 depicts a flowchart showing a specific example

9   of the process utilized by the decoding engine for UPC-A

10   barcodes.

11   FIG. 6A depicts a flowchart showing the "forced

12   decoding" depicted in FIG. 6.

13

14   **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)**

15   The following presents a detailed description of a

16   preferred embodiment (as well as some alternative

17   embodiments) of the present invention. However, it should

18   be apparent to one skilled in the art that the described

19   embodiment may be modified in form and content to be

20   optimized for a wide variety of situations.

21   With reference first to FIG. 1, shown is a schematic

22   diagram of the network configuration utilized in the

23   preferred embodiment of the present invention. In this

24   figure, product 101 contains barcode 103 which may be

1　placed on product 101 in a variety of ways. For example,

2　barcode 103 may be printed directly onto product 101

3　utilizing conventional printing techniques. Alternatively,

4　barcode 103 may be affixed to product 101 utilizing a

5　sticker, tag, etc.

6　　　Barcode 103 may be any machine-readable code utilizing

7　either a public standard encoding symbology or a

8　proprietary symbology. Some examples of one and two

9　dimensional symbologies include, but are not limited to,

10　UPC-A, UPC-E, ISBN, RSS-14, RSS-14E, RSS-14L, Interleaved 2

11　of 5, EAN/JAN-8, EAN/JAN-13, Code 39, Code 39 Full ASCII,

12　Code 128, PDF417, QR Code, Data Matrix, and Optical

13　Intelligence 2D.

14　　　To scan barcode 103, a user utilizes mobile device 105

15　with attached or embedded digital camera 107. Mobile

16　device 105 may be any device capable of digitally imaging

17　barcode 103 such as a camera phone, mobile phone with

18　camera attachment, PDA, PDA with camera attachment, Pocket

19　PC, Palm device, laptop, desktop, etc.

20　　　First, the user takes a picture of barcode 103 using

21　embedded digital camera 107. Once an image of barcode 103

22　has been acquired by mobile device 105, the barcode image

23　is sent to server 113 via MMS message 111 through wireless

1 network 109. ScanZoom software loaded on server 113

2 decodes the barcode.

3   Server 113 may process the decoded barcode information

4 in many different ways. In a first embodiment, server 113

5 may use relational database 114 to pull up product

6 information pertaining to product 101. The server would

7 then forward the product information to mobile device 105

8 via a SMS/MMS message. If a MMS message is sent to mobile

9 device 105, this may cause a WAP browser loaded on mobile

10 device 105 to be redirected to the appropriate site. The

11 MMS message may also forward a "link" to the user which can

12 be used to direct mobile devices' 105 to a website.

13   However, on some devices, sending a link as an MMS is

14 not an option. For these devices, a SMS message can be

15 sent to mobile device 105 which contains a link which can

16 be added to the user's favorites/bookmarks. An additional

17 SMS message can also be sent to indicate to the user that

18 the barcode has been properly decoded.

19   In a second embodiment, server 113 may process the

20 decoded barcode information by using relational database

21 114 to pull up product information related to product 101

22 and then utilize search engine 117 to search for similar

23 products or information pertaining to it. The results of

24 the search would then be sent to mobile device 105 via a

1   SMS/MMS message. As should be evident from these two

2   described embodiments, the barcode information can be

3   utilized in an almost limitless amount of ways.

4   To provide additional security, a user of mobile

5   device 105 may be prompted to provide a username and/or

6   password to access server 113. Server 113 would use user

7   database 119 to properly authenticate users. Users not

8   having an account contained in user database 119 would not

9   be granted access to server 113 in any capacity.

10   Referring next to FIG. 2, shown is the process

11 utilized by ScanZoom to decode barcode 103. A user first

12 takes a picture of barcode 103 in step 201. Generally, the

13 user utilizes a "preview" window to properly center and

14 align the barcode before taking the picture. After the

15 barcode image has been acquired, the user sends the picture

16 to server 113 via wireless network 109 in step 203. For

17 example, the picture may be sent to server 113 via MMS

18 message 111. However, any protocol or message type which

19 allows for the communication of images over a wireless

20 network may be utilized with the present invention.

21   After the barcode image has been received by server

22 113, it is decoded by the ScanZoom software in step 205.

23 Decoding barcode 103 generally involves two steps. First,

24 the barcode image is processed by server 113 to enhance the

1 barcode image. This allows the barcode to be decoded more

2 easily. Once the barcode image has been enhanced, decoding

3 engine 303 decodes the barcode information from the barcode

4 image. If the software cannot decode barcode 103 on a

5 first attempt in step 205, the ScanZoom software attempts

6 to decode the image a finite amount of times utilizing

7 different parameters.

8 The barcode information can then be processed by

9 server 113 in step 207. For example, server 113 may use

10 relational database 114 to look up product information

11 pertaining to the decoded barcode information. This media

12 content is then sent back to mobile device 105 in step 209.

13 Preferably, the media content is sent to mobile device 105

14 via a SMS message or a MMS message, as these are two

15 commonly used methods of transmitting information among

16 wireless devices. However, any method of transmitting

17 media content from server 113 to mobile device 105 may be

18 utilized with the present invention. After the media

19 content has been received by mobile device 105, it is

20 subsequently displayed to the user in step 211.

21 Turning next to FIG. 3, shown is a schematic diagram

22 depicting the product architecture of the ScanZoom

23 software. Decoding engine 303 (utilized in step 205 of

24 FIG. 2) is responsible for decoding barcode 103 acquired

1   via digital camera 107. Decoding engine 303 is designed to

2   accommodate variations in brightness and contrast in the

3   scanned image of barcode 103. This is done through use of

4   globally and locally adaptive image processing operations.

5   Exposure levels can be very high or very low, without

6   significant adverse affect on success of decoding. If

7   contrast is low either because the ink presents little

8   contrast with the substrate, or because the lighting

9   conditions are poor, decoding engine 303 may still decipher

10 barcode 103. Even highly variable shading within an image

11 is recognized and compensated for. The underlying

12 technique utilized by decoding engine 303 to recognize

13 features of barcode 103 is the detection of local pixel

14 intensity patterns that may signal the presence of

15 particular barcode features. This is in contrast to the

16 approach of typical decoding algorithms for more highly

17 controlled commercial scanner or laser gun environments

18 which typically do fixed thresholding or limited digital

19 filtering which presumes a highly controlled environment

20 and lighting configuration.

21   Decoding engine 303 is able to decode one and two

22 dimensional barcodes with a CIF (typically 352x288) imager,

23 and essentially all commonly used barcodes with a VGA

24 (640x480) imager. Increasing the imager resolution

1 generally improves the usability, decoding speed, and

2 accuracy while increasing the range of viable barcodes.

3   In ordinary application usage, decoding engine 303

4 does not require special illumination sources due to its

5 ability to decode barcodes from images with low contrast.

6 For color imagers, decoding engine 303 utilizes specific

7 image processing algorithms in order to avoid problematic

8 image artifacts during the translation from color to

9 grayscale. Decoding engine 303 utilizes fast image

10 processing algorithms to perform the conversion so that the

11 maximum amount of information is preserved, making for a

12 robust, easy to use reader.

13   Decoding engine 303 is also able to cope with moderate

14 amounts of image focus global impairment due to distance

15 and lens focal length issues. Additionally, the decoding

16 algorithm is optimized to work reliably even with

17 appropriate low-cost lenses in inexpensive consumer digital

18 cameras.

19   Furthermore, decoding engine 303 is designed to

20 perform reliably in difficult decoding situations. It is

21 successful in variable light, low contrast, low resolution,

22 focus, and other impaired conditions. These abilities make

23 decoding engine 303 perfectly suited to decode barcode

1   images in a variety of "real world" embedded digital camera

2   device conditions.

3   More specifically, key technical decoding features

4   used in decoding engine 303 include:

5   **Rotation:**

6   Decoding engine 303 enables identification and

7   decoding of most barcodes at any degree of rotation from

8   the normal orientation. Decoding engine 303 is designed

9   for the more general "any orientation" case.

10   **Geometric Distortions:**

11   Decoding engine 303 is tolerant of "aspect ratio,"

12   "shear," "perspective," and other geometric image

13   distortions. These distortions can be caused by a number of

14   things such as the camera line of focus not being

15   perpendicular to the plane of the barcode. Specific

16   algorithms can tolerate deviations from the perpendicular

17   in any direction.

18   **Adaptive Correction:**

19   One of the techniques used in several ways by decoding

20   engine 303 is an adaptive, "multiple hypotheses" approach

21   to detect the presence of specific features within barcode

22   103. In general, while decoding an image of barcode 103, a

23   number of assumptions are made by decoding engine 303 about

24   how characteristic features of barcode 103 are likely to

1   appear in an image. For example, the precise width and

2   intensity of a minimal bar in an image and the threshold at

3   which a data bit in a matrix code is counted as on or off

4   are critical to decoding an image. Initial default

5   estimates of these parameters may be wrong, and only by

6   adaptively correcting them can the image be decoded. Where

7   appropriate, decoding engine 303 will re-examine an image

8   that has failed to decode under one set of assumptions and

9   introduce revised assumptions to improve the likelihood of

10 correctly decoding barcode 103.

11 ***Error Correction:***

12   Decoding engine 303 additionally makes use of

13 sophisticated error correction technology for two-

14 dimensional barcode formats. The standard technique for

15 error correction in dense barcodes is some variant of a

16 "Reed-Solomon" algorithm. Decoding engine 303 uses the

17 full power of this approach. Reed-Solomon techniques can

18 correct a limited number of errors in these guesses.

19 Decoding engine 303 makes guesses on most elements, but

20 also identifies elements that are too poorly imaged or

21 printed to make a reasonable guess. These are "erasures."

22 Reed-Solomon error correction techniques can detect and

23 correct more errors and thus has improved general results

24 when erasures are identified.

1 *Sub-Pixel Precision:*

2   Decoding engine 303 also allows barcode information to

3 be resolved to sub-pixel precision. The algorithms need

4 to, and can, with certain barcode types, retrieve

5 information from a code element occupying an area less than

6 1.5 X 1.5 pixels. Among the techniques employed by

7 decoding engine 303 are specialized adaptive interpolation

8 algorithms that take into account the precise local

9 conditions surrounding the data feature being examined.

10 Local conditions may include differences in lighting or

11 printing quality, or secondary light scattering. Various

12 image kernel operations are available to enhance the local

13 image quality. The resulting outcome is better decoding

14 accuracy, support for higher density codes, and more robust

15 performance.

16   Decoding engine 303 may utilize any number of symbol

17 libraries to resolve the correct barcode information. As

18 shown, decoding engine 303 may access UPC-A/E library 307,

19 RSS library 309, OI library 311, PDF417 library 313, QR

20 code library 315, Code 39 library 317, Code 128 library

21 319, EAN library 321, and JAN library 323.

22   Now referring to FIG. 4A, shown is a flowchart of the

23 steps utilized by decoding engine 303 to enhance the image

24 of barcode 103. First, decoding engine 303 converts the

1   barcode image to a black and white image using a standard

2   image filter in step 400. Afterward, decoding engine 303

3   de-skews the barcode image in step 401. Generally, skew

4   occurs when the barcode picture is taken at an angle. To

5   compensate for this effect, decoding engine 303 first

6   identifies the angle(s) of skew in the image and processes

7   the picture accordingly to remove the skew.

8   Next, decoding engine 303 attempts to repair images

9   which exhibit yaw in step 403. Yaw occurs when the barcode

10   or camera is moved during exposure, causing the image to

11   exhibit streaks. Decoding engine 303 removes the yaw from

12   images by using a filter specifically designed to remove

13   such effects.

14   Once the skew and yaw in the image has been corrected,

15   decoding engine 303 attempts to remove any rotation of the

16   barcode from the normal orientation which may have occurred

17   during imaging. This may be accomplished in a variety of

18   ways in step 405. For example, decoding engine 303 may

19   first identify the angle of rotation of the image. This is

20   much simpler for one-dimensional barcodes, but is also

21   possible for two-dimensional barcodes. For one-dimensional

22   barcodes, decoding engine 303 only has to calculate the

23   angle at which the parallel bars in the barcode are rotated

24   from the normal orientation. Once this has been

1   determined, decoding engine 303 can apply a rotation

2   function to the image to return the barcode image to the

3   normal orientation.

4   Returning two-dimensional barcodes to a normal

5   orientation requires much more processing because two-

6   dimensional barcodes contain data in both the horizontal

7   and vertical directions. To determine the angle of

8   rotation, the barcode must be analyzed from at least two

9   orientations, preferably perpendicular to each other. The

10   results of the two analyzations can then be utilized to

11   determine the angle of rotation of the two-dimensional

12   barcode. The same rotation function used for one-

13   dimensional barcodes, previously described, can also be

14   used for two-dimensional barcodes to return the barcode

15   image to the normal orientation.

16   Next, decoding engine 303 sharpens the image using

17   either a standard sharpening filter or a proprietary filter

18   in step 406. The sharpening filter algorithm, described in

19   FIG. 5A, has been shown to be effective for sharpening

20   images containing barcodes. First, the sharpening

21   algorithm converts the gray-scale barcode image is broken

22   down into a two-dimensional array in step 501. Each entry

23   in the two-dimensional array stores the horizontal and

24   vertical coordinates (i.e., the "x" and "y" coordinates) of

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1 a single pixel. The image is then divided into an equal

2 number of vertical sections in step 503. The number of

3 sections ("ns") is equal to the width of the image (in

4 pixels) divided by the desired width of the sections

5 ("ws"). The width of the sections can either be user

6 defined or automatically defined depending upon the size of

7 the image. This converts the image to a three-dimensional

8 array since each pixel also has an assigned section.

9   After the image has been divided into sections, the

10 sharpening algorithm determines the minimum intensity of a

11 pixel in each section in step 505. The image is then

12 processed linearly section by section in step 507. This is

13 done by assigning a pixel intensity of zero to all pixel

14 intensities which are below a threshold black level. The

15 threshold black level is initially user-defined and changes

16 for each image or section being processed depending upon a

17 threshold modulator. In contrast, all pixel intensities

18 having a pixel value above a threshold white value are

19 assigned a pixel intensity of 255.

20   A pixel is also assigned a zero intensity if:

21   1. The value of the pixel lies within a predetermined

22   range of the minimum pixel intensity for that section;

23   or

1   2. The intensity of pixels surrounding a certain pixel

2   has an intensity that lies within the predetermined

3   range of minimum pixel intensity for that section.

4   After the image of the barcode has been processed in

5   step 507, the sharpening algorithm renders the processed

6   image sections back into an image. An example input and

7   output barcode which have been processed by the

8   aforementioned sharpening algorithm are shown in FIG. 5B

9   and FIG. 5C, respectively. The outputted image of FIG. 5C

10   has a much higher chance of being properly decoded than the

11   inputted image of FIG. 5B.

12   Now referring back to FIG. 4A, decoding engine 303

13   applies an edge enhancement filter to the image in step

14   407. This further removes any image anomalies which may

15   have occurred during imaging or conversion to black and

16   white. Once the edges are enhanced, decoding engine 303

17   counts the number of edges which occur in the barcode image

18   in step 409. An edge is a point in the image where there

19   is a sudden change in the color values of the image. An

20   edge that defines a transition from white to black (light

21   to dark) is called a rising edge and an edge that defines

22   the transition from black to white (dark to light) is

23   called a falling edge. Since the quality of the image

24   returned by the camera of the cell phone isn't of a very

1 good quality, the edge detection process relies on the

2 series of approximations and sub processes. Thus the edge

3 detection of step 409 returns a collection of edges (i.e.,

4 points where it is believed that the value of the color

5 changed from dark to light or light to dark).

6   If the number of detected edges is less than 25 as

7 checked in step 411, decoding algorithm 303 attempts to

8 adjust the barcode image again using a new set of

9 assumptions in step 413. The image is then reprocessed

10 using an unaltered version of the image stored in a buffer.

11 If more than 25 edges are not detected after a number of

12 iterations, the ScanZoom application informs the user that

13 a barcode could not be located and the application

14 terminates.

15   However, if the number of edges if found to be greater

16 than or equal to a certain minimum defined number, decoding

17 engine 303 advances to the flowchart of FIG. 4B. As shown

18 in the flowchart, decoding engine 303 loads a first

19 symbology library in step 451. The symbology library may

20 be UPC-A/E library 307, RSS library 309, OI library 311,

21 PDF417 library 313, QR code library 315, Code 39 library

22 317, Code 128 library 319, EAN library 321, and JAN library

23 323 (see FIG. 3). Decoding engine then compares the number

24 of edges a barcode needs to be in this library to the

1   number of edges detected in the actual scanned barcode in

2   step 453. If the number of edges does not match, decoding

3   engine 303 loads the next symbology library in step 455 and

4   repeats the edge comparison with the new library.

5   Detection engine 303 continues this comparison until a

6   match is found.

7   When a match is found in step 453, decoding engine 303

8   proceeds to find the start of the barcode in step 457.

9   Decoding engine 303 next calculates the width of each block

10 in the barcode in step 459.

11   Decoding engine 303 then loads the barcode information

12 from the first block (i.e., the width of the two bars and

13 two spaces contained within the first block) in step 460.

14 The strip width of the first block can then be calculated

15 in step 461. Using the strip width, decoding engine 303

16 calculates the relative widths of each bar/space in the

17 block in step 463. The relative width is defined to be the

18 width of the bar or space divided by the strip width. The

19 resulting relative widths can then be used to calculate the

20 first character of the barcode utilizing a lookup table for

21 the first symbology library.

22   Decoding engine 303 next determines whether all of the

23 characters have been decoded in step 466. If all the

24 characters have not been decoded, decoding engine 303 loads

1 the information from the next block in step 468 and repeats

2 steps 463 – 465 until all characters are decoded from all

3 blocks. Once this has been accomplished, decoding engine

4 303 determines if the decoded character set is a valid code

5 according to the first symbology library in step 467. If

6 the code is valid, decoding engine 303 terminates in step

7 469 and the barcode data is forwarded to the messaging

8 system (see FIG. 2, step 209).

9   However, if the code is not valid according to the

10 first symbology library, decoding engine 303 attempts a

11 "force decode" in step 471 utilizing an alternative method

12 of decoding. If this method is successful, decoding engine

13 303 terminates in step 469 and the barcode data is

14 forwarded to the messaging system (see FIG. 2, step 209).

15 If not, decoding engine 303 loads the next symbology

16 library and repeats steps 453-467 until a valid code is

17 found according to the loaded symbology library.

18   While the foregoing embodiments of the invention have

19 been set forth in considerable detail for the purposes of

20 making a complete disclosure, it should be evident to one

21 skilled in the art that multiple changes may be made to the

22 aforementioned description without departing from the

23 spirit of the invention.